



INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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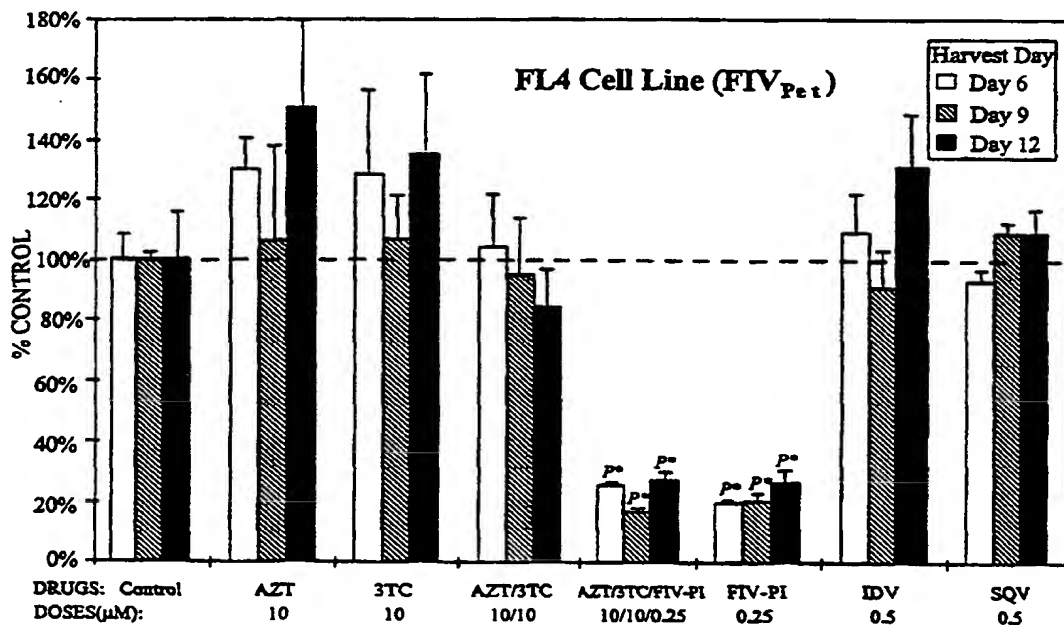
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60/087,281 29 May 1998 (29.05.98) US  
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(54) Title: COMBINATION THERAPY FOR TREATMENT OF FIV INFECTION



(57) Abstract

The subject invention pertains to methods for therapeutic and prophylactic treatment of cats against FIV infection. Methods of the present invention utilize a combination of antiretroviral compounds to treat or prevent FIV infection in a feline animal. In one embodiment, the method comprises administering an effective amount of AZT and another nucleoside analog, such as, for example, 3TC to the animal. In another embodiment, cats are given an effective dose(s) of AZT, 3TC and a retroviral protease inhibitor.

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**A61P 37/00**

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**IS, JP, KP, KR, LC, LK, LR, LT, LV, MG, MK, MN, MX,**  
**NO, NZ, PL, RO, SG, SI, SK, SL, TR, TT, UA, US, UZ,**  
**VN, YU, ZA.**

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(84) Designated States (regional): **ARIPO** patent (GH, GM,  
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BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC,  
NL, PT, SE), **OAPI** patent (BF, BJ, CF, CG, CI, CM, GA,  
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(72) Inventors; and

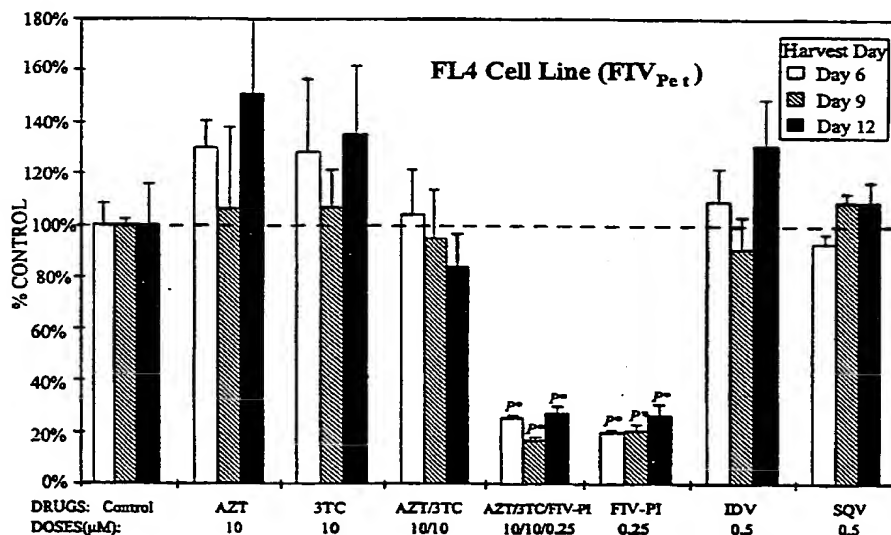
(75) Inventors/Applicants (for **US** only): **DUNN, Ben, M.**  
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[Continued on next page]

(54) Title: **COMBINATION THERAPY FOR TREATMENT OF FIV INFECTION**



(57) Abstract: The subject invention pertains to methods for therapeutic and prophylactic treatment of cats against FIV infection. Methods of the present invention utilize a combination of antiretroviral compounds to treat or prevent FIV infection in a feline animal. In one embodiment, the method comprises administering an effective amount of AZT and another nucleoside analog, such as, for example, 3TC to the animal. In another embodiment, cats are given an effective dose(s) of AZT, 3TC and a retroviral protease inhibitor.

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*For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.*

**(15) Information about Correction:**

**Previous Correction:**

see PCT Gazette No. 08/2000 of 24 February 2000, Section II

# INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 99/11940

**A. CLASSIFICATION OF SUBJECT MATTER**  
IPC 6 A61K31/70 A61P37/00

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 A61K A61P

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X, P	DE 197 03 131 A (BAYER AG) 30 July 1998 (1998-07-30) page 14, line 1-10; claim 5 ---	1-4
X	WO 97 03055 A (SLOAN KETTERING INST CANCER ; PROCHASKA HANS J (US)) 30 January 1997 (1997-01-30) page 21; claims 6, 11, 14, 16; figure 1.6 ---	1-4
X	WO 96 22778 A (UNIV EMORY) 1 August 1996 (1996-08-01) page 8, line 1-5; claim 10 ---	1-4
X	WO 97 49411 A (GLAXO GROUP LTD ; BARRY DAVID WALTER (US); ST CLAIR MARTHA HEIDER ( ) 31 December 1997 (1997-12-31) abstract; claim 13 page 6, line 1-15 --- -/-	1-4



Further documents are listed in the continuation of box C.



Patent family members are listed in annex.

\* Special categories of cited documents :

- \*A\* document defining the general state of the art which is not considered to be of particular relevance
- \*E\* earlier document but published on or after the international filing date
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- \*T\* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- \*X\* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- \*Y\* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- \*S\* document member of the same patent family

Date of the actual completion of the international search

28 April 2000

Date of mailing of the international search report

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Name and mailing address of the ISA

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Gonzalez Ramon, N

# INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 99/11940

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 96 23509 A (MERCK & CO INC) 8 August 1996 (1996-08-08) abstract; claims 3,6,10,13 ---	1-4
X	WO 96 30025 A (WELLCOME FOUND ;BARRY DAVID WALTER (US); ST CLAIR MARTHA HEIDER (U) 3 October 1996 (1996-10-03) abstract; figure 1 page 5, paragraph 4 ---	1-4
E	WO 99 55372 A (GLAXO GROUP LTD ;CURRIE ROBIN (US); JAIN SUNIL (US); WOOD ALLEN WA) 4 November 1999 (1999-11-04) abstract; claim 1 ---	1-4
E	WO 99 66936 A (NOVIRIO PHARMACEUTICALS LIMITE;BRYANT MARTIN L ; MYERS MAUREEN W ( ) 29 December 1999 (1999-12-29) abstract; claims 4,11,22,42,53 ---	1-4
Y	SMYTH N.R. ET AL: "Susceptibility in cell culture of feline immunodeficiency virus to eighteen antiviral agents." JOURNAL OF ANTIMICROBIAL CHEMOTHERAPY, (1994) 34/4 (589-594)., XP000904799 abstract; table 1 ---	1-4
Y	SMITH R.A. ET AL: "A novel Met-to-Thr mutation in the YMDD motif of reverse transcriptase from feline immunodeficiency virus confers resistance to oxathiolane nucleosides." JOURNAL OF VIROLOGY, (1997) 71/3 (2357-2362)., XP000891900 see discussion abstract ---	1-4
X	SMITH R A ET AL: "A novel point mutation at position 156 of reverse transcriptase from feline immunodeficiency virus confers resistance to the combination of (-)-beta-2',3'-dideoxy-3'-thiacytidine and 3'-azido-3'-deoxythymidine." JOURNAL OF VIROLOGY, (1998 MAR) 72 (3) 2335-40., XP000891901 see discussion abstract; figure 3 -----	1-4

# INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US 99/11940

## Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:  
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☒ Claims Nos.: 1, 3, 4  
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:  
see FURTHER INFORMATION sheet PCT/ISA/210
3. ☐ Claims Nos.:  
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

## B x II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see FURTHER INFORMATION PCT/ISA/210

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:  
1-4

### Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest.  
☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/SA/ 210

1. Claims: 1-4

Method of treating or preventing infection of feline immunodeficiency virus administering azidothymidine (AZT) and another nucleoside analog.

2. Claims: 5-12

Method of treating or preventing infection of feline immunodeficiency virus administering a combination of azidothymidine (AZT), another nucleoside analog and an inhibitor of a retroviral protease. Kits containing the same.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

Continuation of Box I.2

Claims Nos.: 1,3,4

Present claims 1,3,4 relate to a compound defined by reference to the following parameter: "nucleoside analog". The use of these parameters in the present context is considered to lead to a lack of clarity within the meaning of Article 6 PCT. It is impossible to compare the parameters the applicant has chosen to employ with what is set out in the prior art. The lack of clarity is such as to render a meaningful complete search impossible.

The claims cover all compounds having this characteristic or property, whereas the application provides support within the meaning of Article 6 PCT and/or disclosure within the meaning of Article 5 PCT for only a very limited number of such compounds. In the present case, the claims so lack support, and the application so lacks disclosure, that a meaningful search over the whole of the claimed scope is impossible. Independent of the above reasoning, the claims also lack clarity (Article 6 PCT). Again, this lack of clarity in the present case is such as to render a meaningful search over the whole of the claimed scope impossible. Consequently, the search for the first invention has been carried out for those parts of the claims which appear to be clear, supported and disclosed, namely those parts relating to the compounds specifically mentioned in the examples and in claim 2 with due regard to the general idea underlying the present application.

The applicant's attention is drawn to the fact that claims, or parts of claims, relating to inventions in respect of which no international search report has been established need not be the subject of an international preliminary examination (Rule 66.1(e) PCT). The applicant is advised that the EPO policy when acting as an International Preliminary Examining Authority is normally not to carry out a preliminary examination on matter which has not been searched. This is the case irrespective of whether or not the claims are amended following receipt of the search report or during any Chapter II procedure.

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/US 99/11940

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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International Application No

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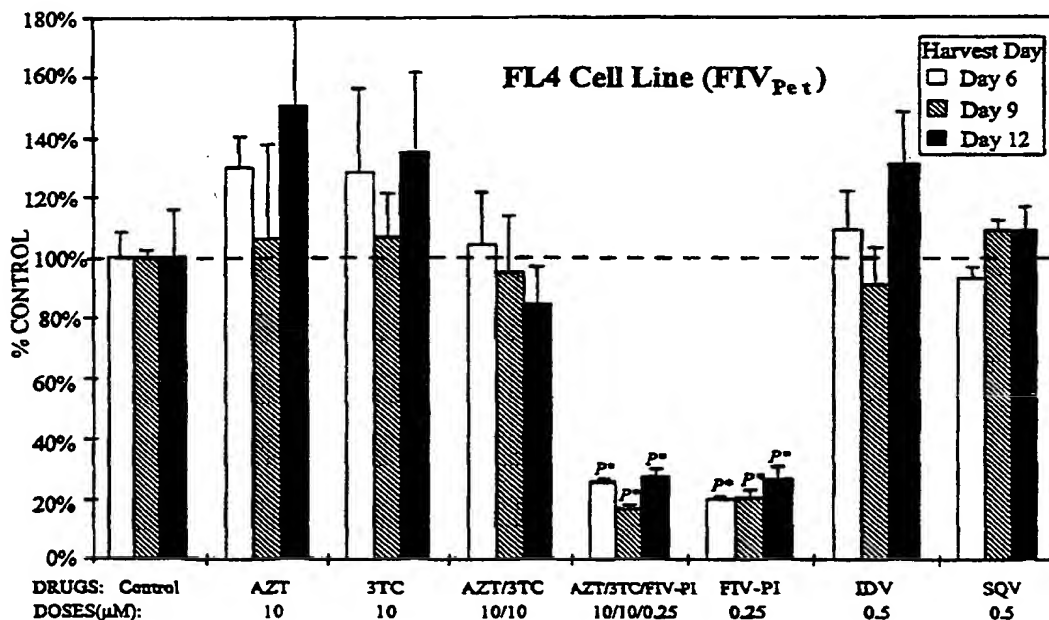
Patent document cited in search report		Publication date	Patent family member(s)		Publication date
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DESCRIPTIONCOMBINATION THERAPY FOR TREATMENT  
OF FIV INFECTION

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The subject invention was made with government support under a research project supported by NIH Grant AI30904. The government has certain rights in this invention.

10

Background of the Invention

Feline immunodeficiency virus (FIV) is a lentivirus which causes immunodeficiency syndrome in domestic cats (Pedersen *et al.*, 1987; Siebelink *et al.*, 1990). FIV closely resembles human immunodeficiency virus (HIV) in genomic, biochemical, and morphologic characteristics as well as clinical and hematological manifestations (Johnson *et al.*, 1994; Pedersen *et al.*, 1987; Yamamoto, Sparger *et al.*, 15 1988). As a result, FIV infection of domestic cats is considered to be an excellent small animal model for testing prophylactic and therapeutic strategies against AIDS viruses (Gardner, 1991; Johnson *et al.*, 1994). A number of antiretroviral drugs for HIV, including the prototype nucleoside analogue azidothymidine (AZT), has been tested 20 using the FIV model (Hart *et al.*, 1995; Hartmaun *et al.*, 1992; Hayees *et al.*, 1993; Hayees *et al.*, 1995; Meers *et al.*, 1993; North *et al.*, 1989; Smith *et al.*, 1994).

The therapeutic use of AZT has been unremarkable in cats and was unable to delay the spread of FIV infection *in vivo* (Hart *et al.*, 1995; Hartmaun *et al.*, 1992). Prophylactic AZT treatment of experimental cats caused either a delay or decrease in 25 both infected blood lymphocyte numbers and plasma virus load (Hayees *et al.*, 1993; Hayees *et al.*, 1995; Meers *et al.*, 1993; Smith *et al.*, 1994). In addition, a delay in FIV antibody production was observed in some animals (Smith *et al.*, 1994). However, prophylactic therapy with AZT did not protect cats from FIV infection (Meers *et al.*, 1993; Hayees *et al.*, 1993; Hayees *et al.*, 1995; Smith *et al.*, 1994). As reported for HIV 30 therapy, withdrawal of the drug resulted in a resurgence of the virus in these cats. When compared to the untreated group, significantly higher CD4 and CD8 cell counts were observed shortly after the withdrawal of the drug (Hayees *et al.*, 1993; Hayees *et al.*,

1995). However, CD4/CD8 ratios were not significantly different from the untreated cats. In contrast, FIV-infected cats therapeutically treated with AZT had no change in FIV antigen or anti-FIV antibody titers but had transient improvement in CD4/CD8 ratios and clinical signs (Hart *et al.*, 1995; Hartmaun *et al.*, 1992). These findings suggest that  
5 monotherapy with AZT has limited benefit as a therapy for FIV infection. Similar observations have been made with AZT monotherapy of HIV-infected individuals (Harrigan, 1995; Staszewski, 1995).

In recent trials, combination therapies with AZT and other antiretroviral drugs, such as phosphonomethoxyethyl adenine and dideoxycytidine 5'-triphosphate, had  
10 minimal to no effect in preventing or controlling FIV infection in cats (Hartmaun *et al.*, 1992; Magnani *et al.*, 1994; Philpott *et al.*, 1992). The *in vivo* use of viral protease inhibitors or new nucleoside analogue combinations, such as, for example, lamivudine (3TC) and AZT has yet to be reported in FIV-infected cats. Commercially available HIV protease inhibitors (*e.g.*, Sequinavir (SQV), Indinavir (IDV), Ritonavir, Nelfinavir) do  
15 not inhibit FIV replication in PBMC *in vitro*. Unlike other nucleoside analogues, 3TC rapidly induces mutations which can phenotypically reverse the mutations caused by AZT, enabling the antiviral activity of AZT to persist in the host (Boucher *et al.*, 1993; Larder, 1995; Tisdale *et al.*, 1993). This unique feature of 3TC makes it a prime candidate for use in combination with AZT. In HIV-positive individuals, the  
20 combination AZT/3TC therapy had synergistic or additive effects at decreasing plasma virus load and increasing CD4 cell counts and function (Katlama *et al.*, 1994; Lange, 1995; Paul *et al.*, 1995; Staszewski, 1995). The addition of an HIV protease inhibitor to this combination further decreased the viral load and improved the CD4 cell count (Deeks *et al.*, 1997; Torres *et al.*, 1997).

### Brief Summary of the Invention

The subject invention concerns methods for therapeutic and prophylactic treatment of feline animals against infection by FIV. Methods of the present invention utilize a combination of antiretroviral compounds. In one embodiment, an effective  
30 amount of a composition comprising AZT and another nucleoside such as 3TC. In another embodiment, cats are given an effective dose(s) of a composition comprising

AZT, a nucleoside analog such as 3TC and a retroviral protease inhibitor. In an exemplified embodiment, the protease inhibitor is HBY-793 (Hoescht-Bayer).

#### Brief Description of the Drawings

5           **Figure 1** shows anti-FIV activities of AZT, 3TC, FIV-PI, and HIV-PI (IDV and SQV) in chronically FIV-infected cell lines. The antiviral activity of the drugs at noncytotoxic doses were evaluated in feline T-cell lines chronically infected with either FIV<sub>Pet</sub> (subtype A strain) (panel A), or FIV<sub>Bang</sub> (subtype B strain) (panel B). The RT data are presented as % control, whereby % control represents RT mean of triplicate treated  
10           cultures divided by RT mean of triplicate untreated cultures and multiplied by 100. The RT data on harvest days at 6, 9, and 12 are shown. The results from treated culture sets which are statistically different from the values of the untreated controls are indicated by either  $p < 0.05$  ( $P$ ) or  $p < 0.005$  ( $P^*$ ) based on Student T test.

**Figure 2** shows anti-FIV activities of AZT, 3TC, FIV-PI, and FIV-PI in primary  
15           PBMC infected with FIV<sub>Bang</sub>. Six separate experiments with varying concentrations and combinations were performed and the results from two representative experiments are shown. Nucleoside analogue and PI doses were  $0.1 \mu\text{M}$  in Experiment 1 (panel A) and  $0.05 \mu\text{M}$  and  $0.01 \mu\text{M}$ , respectively, in Experiment 2 (panel B). The RT data are presented as % control and the results from treated culture sets which are statistically  
20           different from the values of the untreated controls are indicated by either  $p < 0.05$  ( $P$ ) or  $p < 0.005$  ( $P^*$ ) based on Student T test. The Harvest Day 16 result for AZT/3TC culture set was statistically different ( $p < 0.03$ ) from the results of AZT culture set and 3TC culture set from the same time point, as indicated by (Y) above AZT/3TC bar (panel A). The Day 9 and 12 harvest results for AZT/3TC/FIV-PI culture set were statistically  
25           different ( $p < 0.05$ ) from the results of AZT/3TC culture set and FIV-PI culture set from the same time points, as indicated by (Z) above AZT/3TC/FIV-PI bars (panel B).

**Figure 3** shows anti-FIV activities of AZT, 3TC, FIV-PI, and HIV-PI in primary  
PBMC infected with FIV<sub>UK-8</sub> (subtype A strain). Four separate experiments with varying concentrations and combinations were performed and the results from two representative  
30           experiments are shown. Nucleoside analogue and P1 doses were  $0.1 \mu\text{M}$  and  $0.01$ - $0.5 \mu\text{M}$ , respectively, in Experiment 1 (panel A) and  $0.05 \mu\text{M}$  and  $0.01$ - $0.5 \mu\text{M}$  respectively, in Experiment 2 (panel B). The RT data are presented as % control and the results from

treated culture sets which are statistically different from the values of the untreated controls are indicated by either  $p < 0.05$  ( $P$ ) or  $p < 0.005$  ( $P^*$ ). Statistical differences existed between the results of AZT/3TC culture set and 3TC culture set at Harvest Days 17 ( $p < 0.02$ ) and 20 ( $p < 0.001$ ) in panel A and Harvest Days 9 ( $p < 0.02$ ), 12 ( $p < 0.04$ ), and 15 ( $p < 0.02$ ) in panel B, as indicated by (X) above the AZT/3TC bars. In addition, statistical difference existed between the results of AZT/3TC culture set and AZT culture set at Harvest Day 20 ( $p < 0.001$ ) in panel A and Harvest Day 15 ( $p < 0.01$ ) in panel B, as indicated by (Z) above the AZT/3TC bars.

**Figure 4** shows the chemical structure of the protease inhibitor designated herein as HBY-793.

#### Detailed Disclosure of the Invention

The subject invention concerns methods for therapeutic and prophylactic treatment of cats against infection by FIV. Methods of the present invention utilize a combination of antiretroviral compounds. In one embodiment, cats can be administered an effective amount of a composition comprising AZT and another nucleoside analog. Preferably, the nucleoside analog is 3TC.

In another embodiment of the methods of the present invention, cats are given an effective dose(s) of a composition comprising AZT, another nucleoside analog and a retroviral protease inhibitor. Preferably, the nucleoside analog is 3TC. In an exemplified embodiment, the protease inhibitor is HBY-793. The structure of HBY-793 is shown in Figure 4. Other retroviral protease inhibitors that can inhibit FIV proteases are contemplated within the scope of this invention.

FIV-infected cats treated according to the methods of the present invention can also be given bone marrow transplantation after total body irradiation in conjunction with the antiretroviral drug combination therapy. The bone marrow transplanted can be either allogeneic or autologous.

The antiretroviral compositions of the subject invention can be administered using standard procedures known in the art. For example, the compositions can be administered as oral or nasal formulations. The compositions can also be administered by parenteral injection, *i.e.*, intravenous, intramuscular, or subcutaneous injection. The

amounts and dosage regimens for administration can readily be determined by the ordinarily skilled clinician.

Cats that are not infected with FIV can be treated according to the methods of the present invention to provide effective prophylactic treatment against FIV infection. FIV-infected cats can be treated according to the subject methods to provide effective therapy for controlling, inhibiting or eliminating FIV infection in that cat.

Results from studies described herein show that the addition of a nucleoside analog like 3TC to prophylactic AZT therapy will completely protect cats against FIV infection. This observation is supported by the *in vitro* findings demonstrating that an AZT/3TC combination was more effective at inhibiting FIV replication in PBMC cultures than single-drug treatments using AZT or 3TC alone. The AZT/3TC combination is effective when used prophylactically or immediately upon FIV exposure. In addition, the combination of antiretroviral drugs AZT/3TC/FIV-PI can be used as an anti-FIV therapy to treat chronically infected animals.

The present invention also concerns kits comprising in one or more containers AZT, another nucleoside analog and an inhibitor of a retroviral protease. Preferably, the nucleoside analog is 3TC. In a preferred embodiment, the retroviral protease inhibitor is HBY-793.

The following abbreviations of FIV strains are used herein:

<u>Strain (subtype)</u>	<u>Abbreviation</u>
Petaluma (A)	FIV <sub>Pet</sub>
Dixon (A)	FIV <sub>Dix</sub>
UK8 (A)	FIV <sub>UK-8</sub>
Bangston (B)	FIV <sub>Bang</sub>
Aomori-1 (B)	FIV <sub>Aom1</sub>
Aomori-2 (B)	FIV <sub>Aom2</sub>
Shizuoka (D)	FIV <sub>Shi</sub>

All references cited herein are incorporated by reference.

Following are examples which illustrate procedures for practicing the invention. These examples should not be construed as limiting. All percentages are by weight and all solvent mixture proportions are by volume unless otherwise noted.

5      Example 1 – *In vitro* Efficacy of AZT, 3TC, and PI

In the first set of *in vitro* studies, feline T-cell lines chronically infected with FIV<sub>Pet</sub> (FL-4 cells) or FIV<sub>Bang</sub> (FIV<sub>Bang</sub>/FeT-J cells) at  $2 \times 10^5$  cells/ml were treated for 3 weeks with a single drug or various combinations of AZT, 3TC, an FIV protease inhibitor (FIV-PI; Hoescht-Bayer HBY-793), and HIV protease inhibitors (HIV-PI) (Fig. 1A and 1B). Saquinavir (SQV) and Indinavir (IDV) were used as the HIV-PIs. Culture supernatants were harvested and the cells were resuspended in fresh culture media containing appropriate drug(s) at 34 day intervals. Viral replication was determined by measuring the levels of reverse transcriptase (RT) activity in the culture supernatants (Rey *et al.*, 1984). Drug toxicity in these cultures were monitored by viability and absolute cell count analyses using trypan blue exclusion method (Mishell *et al.*, 1980). Single and combination drug doses which were determined to be nontoxic to the test cells were used in these studies.

Both single and combination treatments with AZT and 3TC had minimal to no effect at inhibiting RT activity in FIV<sub>Bang</sub>/FeT-J cells (20-50% inhibition) and FL-4 cells (0-10% inhibition). In contrast, FIV-PI treatment inhibited FIV replication by 70-80% in both cell lines (Fig. 1A and 1B). However, the addition of an AZT/3TC combination did not enhance this inhibition. Furthermore, neither SQV nor IDV alone had significant anti-FIV effect (Fig. 1A and 1B). The differences in anti-FIV activities of these nucleoside analogues and FIV-PI may be due to the differences in the mechanism(s) of their antiviral activities. AZT and 3TC exert their antiretroviral activity by preventing the reverse transcription of viral RNA into viral DNA, whereas FIV-PI prevents the production of a whole virion by inhibiting the FIV protease from cleaving viral gag-pro--pol precursor into their individual components. Therefore, cell lines which have proviral integration will not be affected by nucleoside analogues. Based on semi-quantitative PCR analysis, FIV<sub>Bang</sub>/FeT-J cells and FL-4 cells used in current study had proviral integration of 50-80% and >95%, respectively (data not shown). The minor anti-FIV activity of AZT and 3TC observed in FIV<sub>Bang</sub>/FeT-J cells may be due to the antiviral

effect of the nucleoside analogues on the 20-50% of the cells which were still free of FIV proviral integration. As expected, potent anti-FIV activity was observed with FIV-PI in both proviral integrated cell lines.

As a means to simulate *in vivo* conditions, primary peripheral blood mononuclear cells (PBMC) from specific pathogen free (SPF) cats were next used as the indicator cells. Primary PBMC isolated by ficoll hypaque method were stimulated with concanavalin A for 3 days and cultured for an additional 2 weeks before their use in drug studies (Staszewski, 1995). Antiretroviral drug(s) were added to the PBMC cultures ( $1 \times 10^6$  cells/ml) immediately before FIV<sub>Bang</sub> (subtype B) or FIV<sub>UK-8</sub> (subtype A) inoculation of 100 50% tissue culture infectious dose (TCID<sub>50</sub>). Both single and combination treatments with AZT and 3TC inhibited the FIV replication in PBMC at doses which were not toxic to the cells (Fig. 2A and 3A). Synergism in antiviral activities of AZT/3TC combination was observed against both FIV<sub>Bang</sub> and FIV<sub>UK-8</sub> strains (Fig. 2A, 3A, and 3B). The addition of the FIV-PI to the AZT/3TC combination further enhanced the activities of these drugs against FIV<sub>Bang</sub> (Fig. 2B). Such enhancement was not observed against FIV<sub>UK-8</sub> at the doses used (Fig. 3A and 3B). Thus, the anti-FIV activities of AZT, 3TC, and FIV-PI are not restricted to specific FIV strain or subtype, although some strains appear to be more sensitive to one drug over another. Similar to previous studies with chronically infected cells, single-drug treatments with FIV-PI but not HIV-PIs (SQV and IDV) inhibited FIV replication in PBMC cultures (Fig. 2A, 3A, and 3B). Furthermore, addition of SQV or IDV to the AZT/3TC combination did not enhance the antiviral activity of the AZT/3TC combination. The lack of anti-FIV activity of SQV and IDV may be explained by the fact that HIV-PIs do not efficiently bind to FIV protease, whereas the FIV-PI used in this study efficiently binds to HIV protease as well as FIV protease (Dunn *et al.*, 1994; Wlodawer *et al.*, 1995). These results show that dual and triple combinations of AZT, 3TC, and FIV-PI may have therapeutic benefit against FIV infection in domestic cats.

#### Example 2 – Prophylactic Efficacy of AZT/3TC in Cats

Based on the findings from *in vitro* studies, the prophylactic use of AZT/3TC combination was next tested in experimental cats. Four of the eight SPF cats (16-20 weeks of age) received oral administration of AZT and 3TC (75 mg/kg each) twice a day

(BID), while remaining cats received placebo. This treatment dose was based on the *in vivo* research, in which six SPF cats (2 cats per treatment group) treated (BID) with either AZT or 3TC at 100 mg/kg or AZT/3TC combination at 50 mg/kg each had no hematological or clinical abnormalities after two weeks of treatment. In this study, all cats except for one treated cat (#RUI) were inoculated with 100 50% cat infectious dose (C1D<sub>50</sub>) of FIV<sub>UK-8</sub> at 3 days after the first drug or placebo treatment. FIV<sub>UK-8</sub> was used in this study because this strain gave more consistent CD4/CD8 ratio inversion in a larger number of infected cats than did infection with FIV<sub>Bang</sub> or FIV<sub>Pet</sub>. All cats received either the drug or placebo treatments throughout the first 11 weeks after FIV inoculation, unless stated otherwise. The cats were monitored daily for clinical signs and twice a month for hematological changes, FIV load in PBMC and plasma, anti-FIV antibody titers, and CD4/CD8 ratio and absolute counts (Diehi *et al.*, 1995; Green *et al.*, 1993; Okada *et al.*, 1994; Tellier *et al.*, 1997; Yamamoto *et al.*, 1991).

At 4 weeks of treatment, severe anemia was observed in all challenged and unchallenged cats treated with AZT/3TC; therefore, the doses of each drug were lowered to 34 mg/kg each at 4 weeks of treatment and subsequently to 5-10 mg/kg each at 5 weeks of treatment. AZT/3TC treatment was terminated in one cat (#3GB) at 6 weeks of treatment, and the treatment was resumed 6 days later at 5 mg/kg each. Based on virus isolation and PCR analyses, one cat (#101) from the placebo group was positive for FIV by 3 weeks post infection (pi) and had anti-FIV antibodies by 5 weeks pi (Table 1). However, plasma viral RNA levels of this cat were not detected throughout the study; even though the virus load in the PBMC was similar to the levels detected in the remaining placebo cats. These placebo cats (#NK4, #NK6, #IH5) were positive for FIV titers in the plasma and PBMC and for anti-FIV antibodies by 7 weeks pi. Furthermore, all placebo cats, except for cat #101, had transient or persistent CD4/CD8 inversion starting 11 weeks pi. In contrast, all AZT/3TC-treated cats were negative for FIV and had no CD4/CD8 inversion throughout the study. Both drug and placebo treatments were terminated at 11 weeks pi and all cats were monitored for additional 6-13 weeks. In the previous reports, an increase in FIV load of the PBMC was observed after the withdrawal of AZT treatment in FIV-infected cats (Hayees, *et al.*, 1993; Hayees *et al.*, 1995; Meers *et al.*, 1993). Thus, if low levels of FIV infection undetectable by current assays existed in AZT/3TC-treated cats, then such infection should rebound when the drugs are

removed. In this study, all AZT/3TC-treated cats remained negative for FIV in PBMC and anti-FIV antibodies throughout the 6-13 weeks after the withdrawal of the drug treatment. Virus isolation and PCR of bone marrow and lymph node cells performed at the termination of the study further confirmed the FIV-free status of these cats. Thus, complete protection of cats against experimental FIV infection was achieved with prophylactic AZT/3TC therapy.

### Example 3 – Therapeutic Efficacy of AZT/3TC in Chronically FIV-Infected Cats

Based on the *in vivo* toxicity observed in the prophylactic study, three cats (#101, #NK6, #144) chronically infected with FIV<sub>UK-8</sub> for 16 weeks were treated at 20 mg/kg of each drug (BID), while an additional three infected cats (#1H5, #NK4, #158) received placebo. These cats were treated with either drug combination or placebo for 8 weeks and monitored an additional 4 weeks for changes in FIV load and CD4/CD8 values. All parameters monitored were identical to those of the prophylactic study. All treated cats developed either mild or severe anemia by 3.5 weeks of treatment. As a result, both drug doses were lowered to 10 mg/kg. Nevertheless, the anemia in one cat (#144) became so severe by 6 weeks of treatment that the drug treatment was terminated for 1 week and resumed thereafter at a low dose of 5 mg/kg of each drug (BID). Unlike the prophylactic study, no significant differences in either FIV load or CD4/CD8 ratios and absolute counts were observed between the treated and placebo cats (Table 2). This study in combination with the previous studies suggest that doses even as low as 20 mg/kg of each drugs when used over moderate period of time (3.5 weeks or longer) will cause anemia in cats. However, short-term treatment (2 weeks) with high dose combination (75 mg/kg each) is well tolerated by cats.

### Example 4

Allogeneic bone marrow transplantation (BMT) in combination with total body irradiation (TBI) and anti-FIV drug therapy was evaluated as an immune reconstitution therapy for FIV-infected cats. The rationale for this therapy is as follows: (1) TBI will decrease FIV load by destroying recipient's hematopoietic cells, including FIV-infected immunocytes. (2) Anti-FIV drug therapy can block the infection of engrafted donor cells in the BMT recipients. (3) BMT with donor BM cells from uninfected cats will

reconstitute normal hematopoietic system. The TBI/BMT combination alone was unable to decrease the virus load due to rapid infection of engrafted donor cells. A majority of FIV-infected recipients of allogeneic BMT succumbed to graft-versus-host disease, accelerated FIV-related diseases, or their combination. As a result, studies were performed to identify antiretroviral drugs that can be combined with TBI/BMT. Prophylactic therapy with AZT/3TC combination protected 100% of the cats from FIV<sub>UK-8</sub> challenge infection. Moreover, the only FIV-infected cat to survive allogeneic BMT also received concurrent AZT/3TC therapy. This cat had complete hematopoietic engraftment including normal CD8 counts. However, its CD4 counts were only slightly higher than the levels observed before BMT. Furthermore, only slight decrease in plasma virus load was observed during high-dose AZT/3TC therapy. Nonetheless, its anti-FIV antibody titers were 100-fold lower than those before BMT. This cat was still healthy at one year post-BMT and is still responsive to AZT/3TC therapy.

#### Example 5

Recent findings with anti-HIV triple-drug combination have revealed that triple-drug cocktails are unable to immune reconstitute the patient with normal numbers and repertoire of T cell populations or to completely decrease/remove the virus load in the lymphoid tissues within feasible duration of time. As such, autologous bone marrow transplantation (BMT) was tested in combination with antiretroviral drugs as an immune reconstitution therapy for FIV-infected cats. Based on preliminary results, no significant decrease in FIV load or improvement in CD4/CD8 ratios or counts were detected in infected cats that received autologous BMT one (1) day after total body irradiation (TBI). These cats survived the autologous BMT and are currently alive over two years after BMT. This is in contrast to the results from allogeneic BMT of FIV-infected cats, whereby all cats except the one on AZT/3TC therapy succumbed to GVHD, accelerated FIV-disease, or their combination. The extension of the time of BMT after TBI will decrease the infected cell reservoir load and, consequently, fewer infected cells will be available to infect engrafted cells. Addition of antiretroviral drug therapy will prevent any remaining infected cell reservoir from contaminating the engrafted cells.

Example 6 – Pharmaceutical Compositions

Antiviral compounds of the invention can be formulated according to known methods for preparing pharmaceutically useful compositions. *Remington's Pharmaceutical Science* by E.W. Martin describes formulations which can be used in connection with the subject invention. In general, the compositions of the subject invention will be formulated such that an effective amount of the antiviral compounds are is combined with a suitable carrier in order to facilitate effective administration of the composition. It should, of course, be understood that the compositions and methods of this invention may be used in combination with other therapies.

The compositions used in these therapies may also be in a variety of forms. These include, for example, solid, semi-solid, and liquid dosage forms, such as tablets, pills, powders, liquid solutions or suspensions, liposomes, suppositories, injectable, and infusible solutions. The preferred form depends on the intended mode of administration and therapeutic application. The compositions also preferably include conventional pharmaceutically acceptable carriers and adjuvants which are known to those of skill in the art. Preferably, the compositions of the invention are in the form of a unit dose.

Once improvement in condition has occurred, a maintenance dose is administered if necessary. Subsequently, the dosage or the frequency of administration, or both, may be reduced, as a function of the symptoms, to a level at which the improved condition is retained.

It should be understood that the examples and embodiments described herein are for illustrative purposes only and that various modifications or changes in light thereof will be suggested to persons skilled in the art and are to be included within the spirit and purview of this application and the scope of the appended claims.

TABLE 1. AZT/3TC prophylaxis of cats starting 3 days before FIV inoculation

Cat #	AZT/3TC treatment <sup>a</sup>		FIV levels <sup>b</sup>						FIV antibodies <sup>b</sup>				CD4/CD8 ratio <sup>bc</sup>			
	(kg/mg)	FIV	Pre	4 wk	9 wk	11 wk	14 wk	Pre	4 wk	9 wk	11 wk	14 wk	Pre	7 wk	11 wk	14 wk
DH5	75→34→10	+	-/-	-/-	-/-	-/-	-/-	-	-	-	-	-	3.30	2.86	2.62	2.38
3GB	75→34→10→0.5	+	-/-	-/-	-/-	-/-	-/-	-	-	-	-	-	1.56	1.37	1.37	1.47
RU2	75→34→10	+	-/-	-/-	-/-	-/-	-/-	-	-	-	-	-	1.77	1.21	1.18	1.18
RU1	75→34→10	-	-/-	-/-	-/-	-/-	-/-	-	-	-	-	-	2.37	1.62	1.62	1.47
NK4	-	+	-/-	+/+	+/+	+/+	+/+	-	-	+	+	+	1.82	1.55	0.96	0.91
NK6	-	+	-/-	-/+	+/+	+/+	+/+	-	-	+	+	+	1.61	0.92	0.46	0.45
IO1	-	+	-/-	+/+	+/+	+/+	+/+	-	-	+	+	+	3.40	1.73	1.24	1.23
III5	-	+	-/-	-/+	+/+	+/+	+/+	-	-	+	+	+	4.40	1.34	0.60	0.61

a The AZT/3TC treatment was started 3 days before FIV inoculation (-0.4 post-infection) at a dose of 75 mg/kg each and decreased to 34 mg/kg at 4 wk post-infection (pi) and then to 10 mg/kg at 5 wk pi. In one cat (#3GB), the AZT/3TC treatment was withdrawn at 6 wk pi and resumed at a low dose of 5 mg/kg at 7 wk pi. The changes in doses if each drug, including the amount (mg/kg) and time (wk pi), are shown.

b Samples before drug or placebo treatment (Pre) and those at various weeks post-infection (wk) were tested for FIV levels, FIV antibodies, and CD4/CD8 ratios. FIV levels were determined by virus isolation (VI), PCR for FIV provirus in PBMC, and RT-PCR for plasma viral RNA (vRNA). FIV antibodies were determined by immunoblot analysis. In general, RT-PCR for plasma viral RNA was less sensitive than PCR of FIV provirus in PBMC after amplification of infected cells by coculturing.

c Inverted CD4/CD8 ratios are bolded.

TABLE 2. AZT/3TC therapy of FIV-infected cats

Cat No.	AZT/3TC treatment <sup>a</sup> (kg/mg)	FIV load <sup>b</sup> (No. of infected cells in PBMC)				FIV antibodies <sup>b</sup>				CD4/CD8 ratio <sup>b</sup>			
		0 wk	3.5 wk	8 wk	12 wk	0 wk	3.5 wk	8 wk	12 wk	0 wk	3.5 wk	8 wk	12 wk
0 wk→3.5 wk→6-7 wk													
I01	20 → 10	++	+	+	++	+	+	++	++	1.45	1.58	1.71	1.71
NK6	20 → 10	++	++	+	+	++	++	++	++	0.45	1.00	0.64	0.70
144	20 → 10 → 0.5	+++	+++	+++	++	++	++	++	++	0.67	0.74	0.45	0.52
III5	-	++	++	+	ND	++	++	++	++	0.61	0.63	0.73	0.87
NK4	-	++	+	+	+	+	++	++	++	0.91	1.25	1.54	1.54
158	-	+++	+++	+++	++	+	++	++	++	1.08	1.01	1.33	1.06

<sup>a</sup> The doses of each drug were decreased from 20 mg/kg to 10 mg/kg at 3 weeks treatment. Treatment was withdrawn in one cat (#144) at 6 weeks of treatment and resumed one week later at 5 mg/kg. The changes in doses of each drug, including amount (mg/kg) and time (wk after initial treatment), are shown.

<sup>b</sup> Samples before drug or placebo treatments (0 wk) and those at various weeks after initial treatment (wk) were tested for FIV levels, FIV antibodies, and CD4/CD8 ratios. FIV loads were determined by the number of PBMC (50 to 5x10<sup>6</sup> PBMC cocultured with 5x10<sup>6</sup> feeder PBMC) needed for positive virus isolation. Virus isolation results are presented as 50 (++++), 5x10<sup>2</sup> (+++), 5x10<sup>3</sup> (++) and 5x10<sup>4</sup> (+) PBMC from treated and untreated cats needed to isolate FIV from a culture containing 5x10<sup>6</sup> uninfected feeder PBMC. FIV antibody titer is defined as the minimal dilution (in Log<sub>10</sub>) at which antibodies to FIV major core protein (p26) could be detected. Serial log dilutions of serum (10<sup>-4</sup> to 10<sup>-7</sup> dilution) were incubated with immunoblot strip for 2 hrs and processed using the immunoblot method. End point titrations of FIV antibodies are presented as 10<sup>-5</sup> (+) and 10<sup>-6</sup> (++).

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Claims

- 1           1. A method for treating or preventing infection of feline immunodeficiency virus  
2           (FIV) in a feline animal, said method comprising administering to said feline animal an  
3           effective amount of azidothymidine (AZT) and another nucleoside analog.
- 1           2. The method according to claim 1, wherein said another nucleoside analog is  
2           3TC.
- 1           3. The method according to claim 1, wherein said feline animal receives bone  
2           marrow transplantation after total body irradiation.
- 1           4. The method according to claim 3, wherein the transplanted cells are selected  
2           from the group consisting of allogeneic cells and autologous cells.
- 1           5. A method for treating or preventing infection of feline immunodeficiency virus  
2           (FIV) in a feline animal, said method comprising administering to said feline animal an  
3           effective amount of azidothymidine (AZT), another nucleoside analog and an inhibitor  
4           of a retroviral protease.
- 1           6. The method according to claim 5, wherein said another nucleoside analog is  
2           3TC.
- 1           7. The method according to claim 5, wherein said inhibitor of a retroviral  
2           protease is selected from the group consisting of HIV protease inhibitors and FIV  
3           protease inhibitors.
- 1           8. The method according to claim 5, wherein said inhibitor of a retroviral protease  
2           is designated as HBY-793 and has the structure shown in Figure 4.

1           9. The method according to claim 5, wherein said another nucleoside analog is  
2           3TC and said inhibitor of a retroviral protease is designated as HBY-793 and has the  
3           structure shown in Figure 4.

1           10. The method according to claim 5, wherein said feline animal receives bone  
2           marrow transplantation after total body irradiation.

1           11. The method according to claim 10, wherein the transplanted cells are selected  
2           from the group consisting of allogeneic cells and autologous cells.

1           12. A kit comprising in one or more containers AZT, another nucleoside analog  
2           and an inhibitor of a retroviral protease.

1           13. The kit according to claim 12, wherein said another nucleoside analog is  
2           3TC.

1           14. The kit according to claim 12, wherein said inhibitor of a retroviral protease  
2           is designated as HBY-793 and has the structure shown in Figure 4.

1           15. The kit according to claim 12, wherein said another nucleoside analog is 3TC  
2           and said inhibitor of a retroviral protease is designated as HBY-793 and has the structure  
3           shown in Figure 4.

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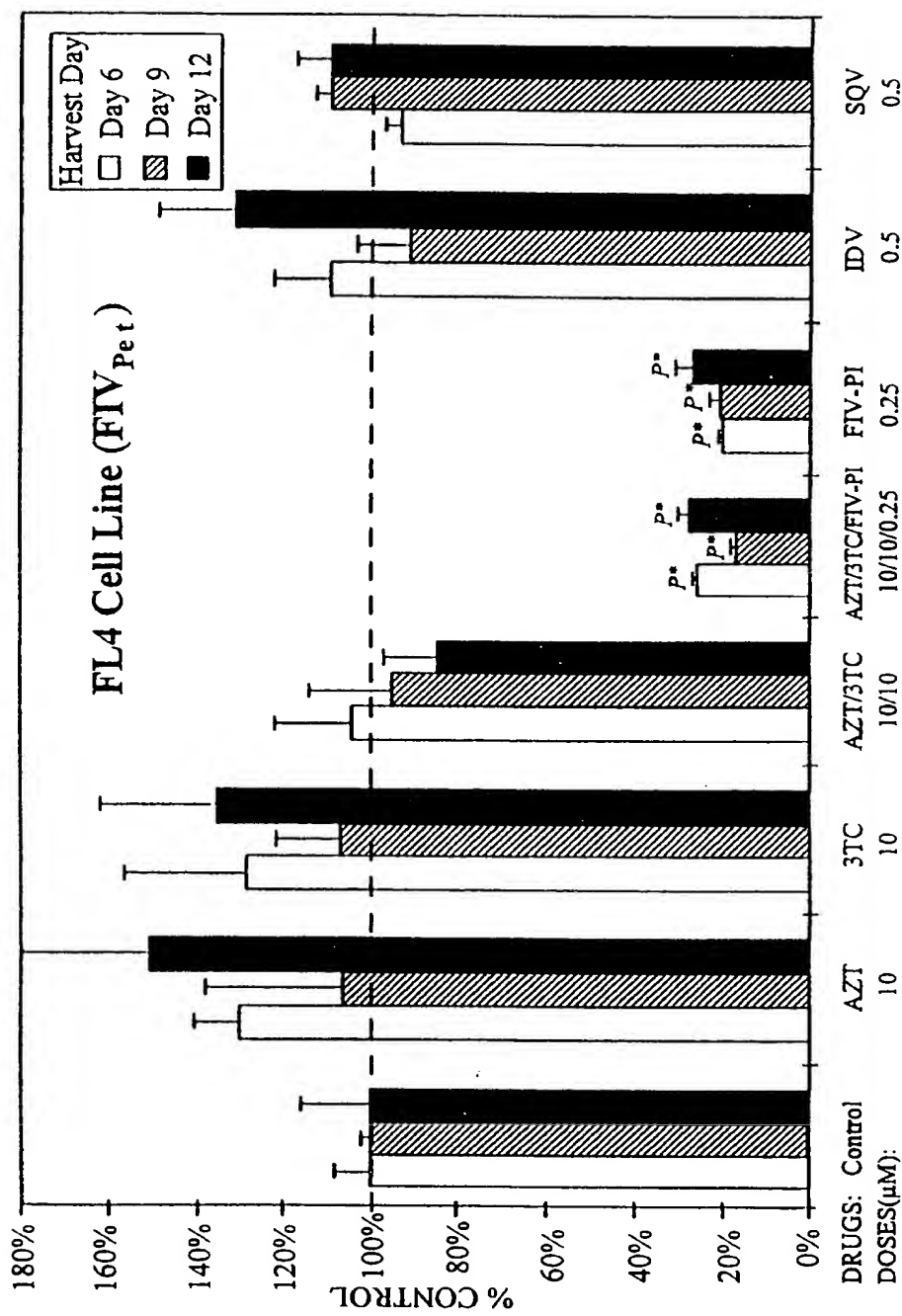


FIG. 1A

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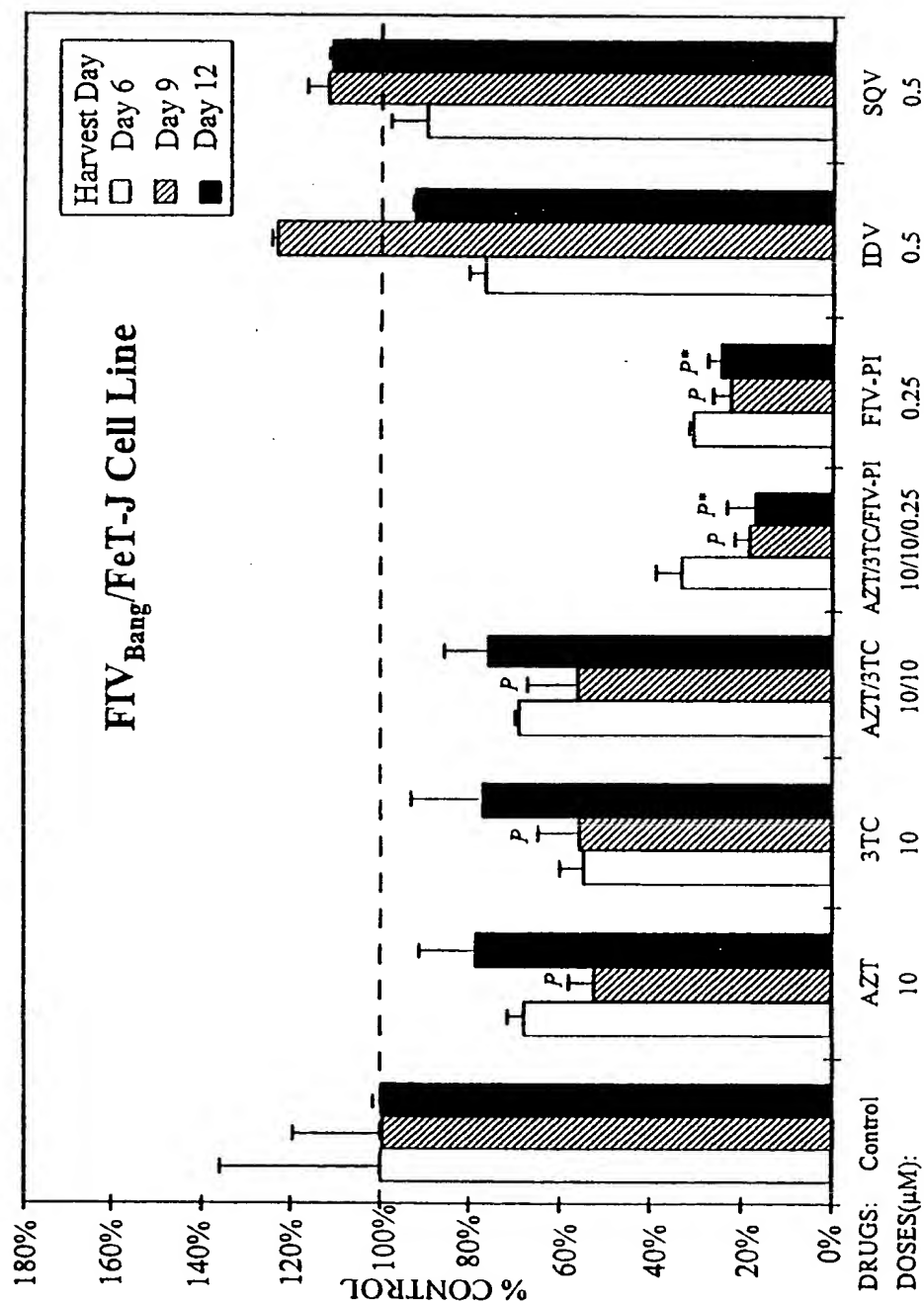


FIG. 1B

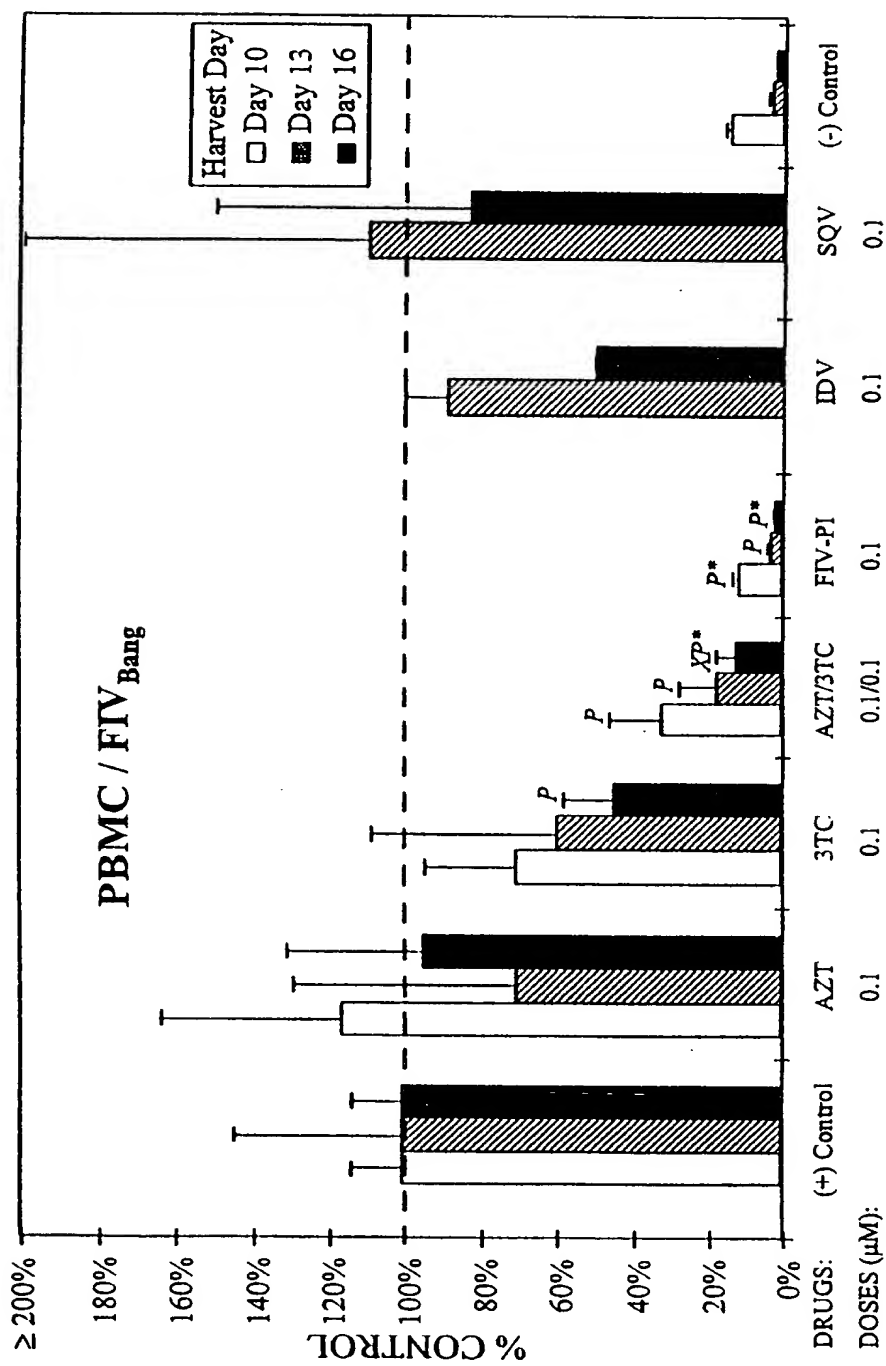


FIG. 2A

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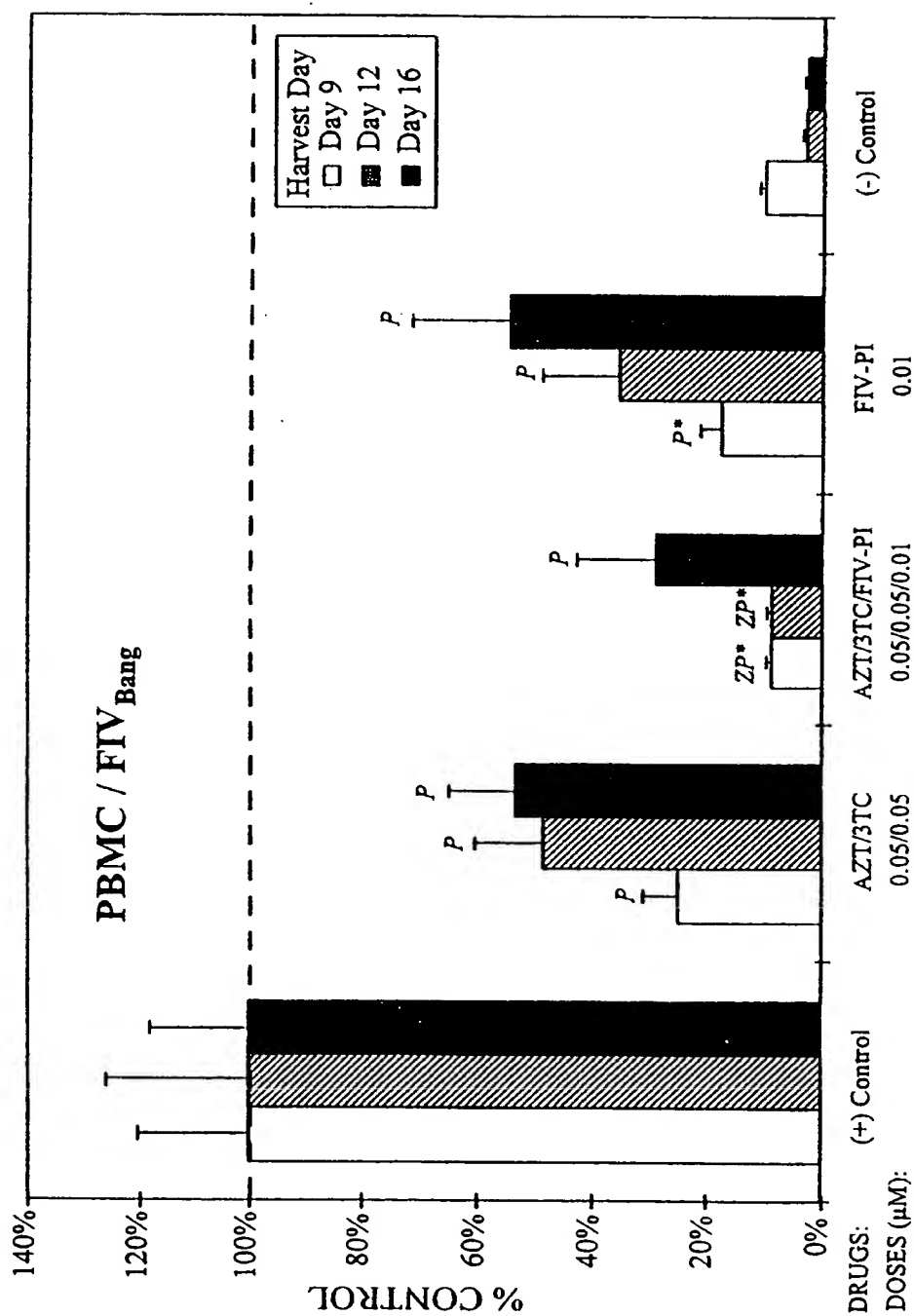


FIG. 2B

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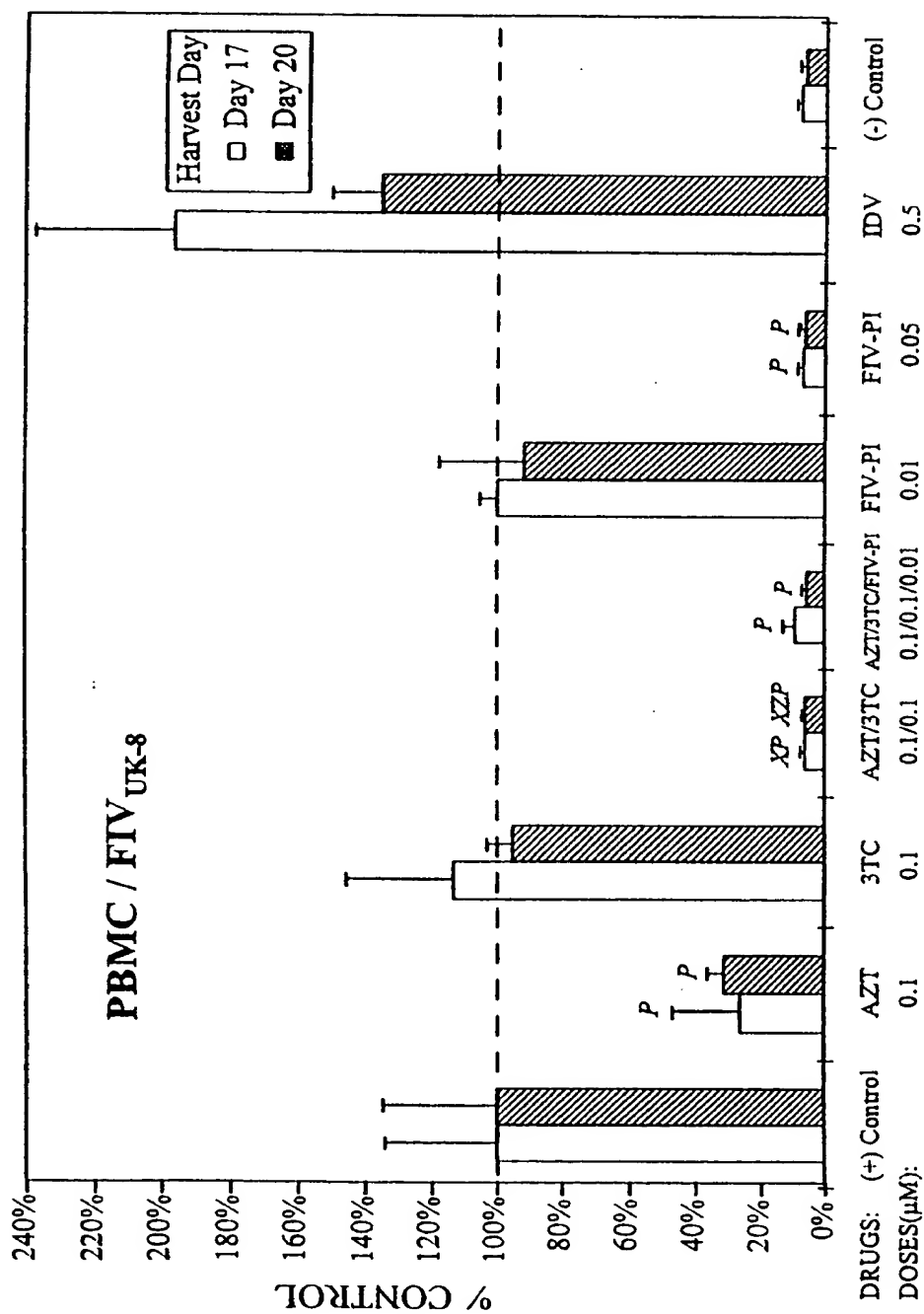


FIG. 3A

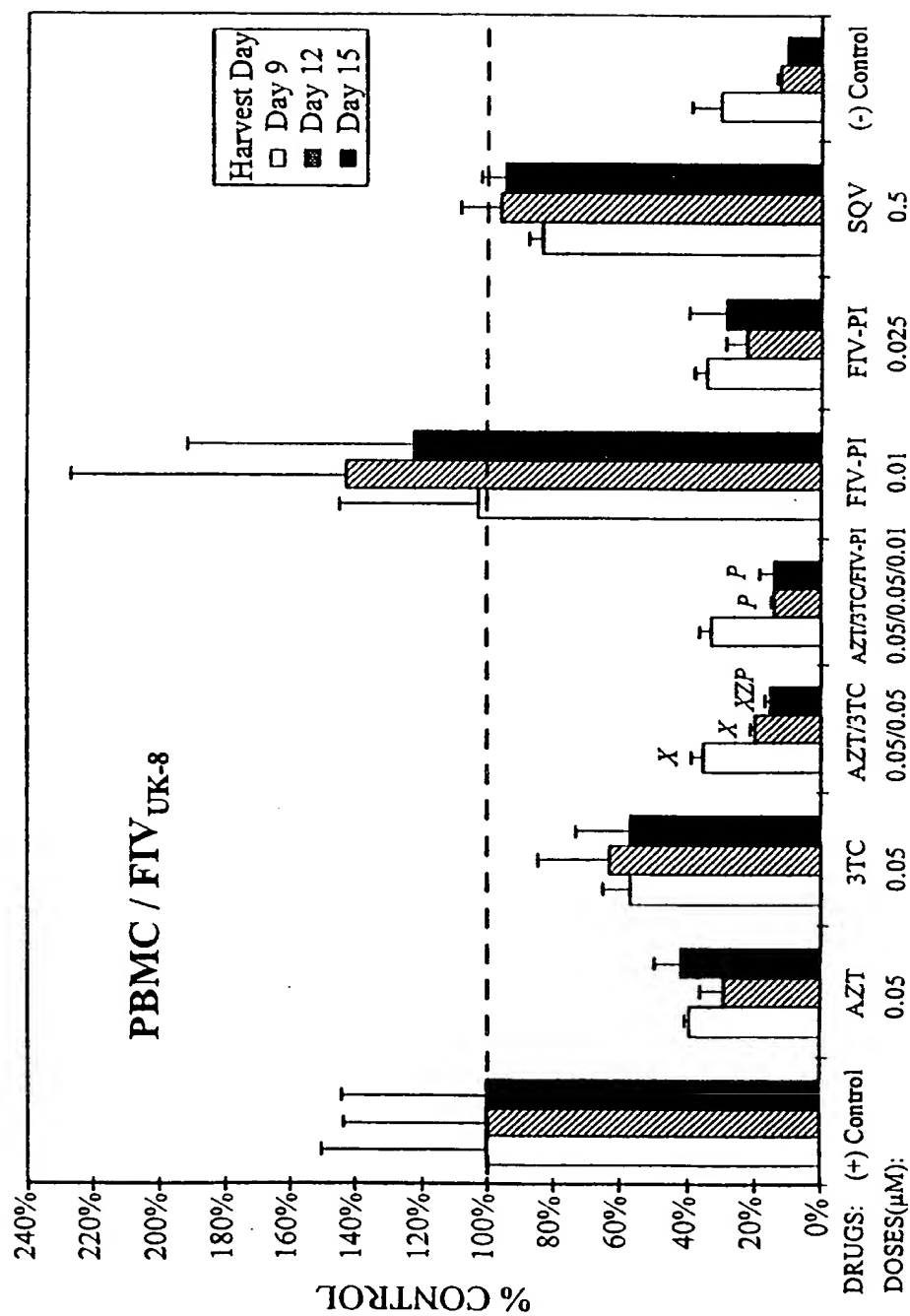


FIG. 3B

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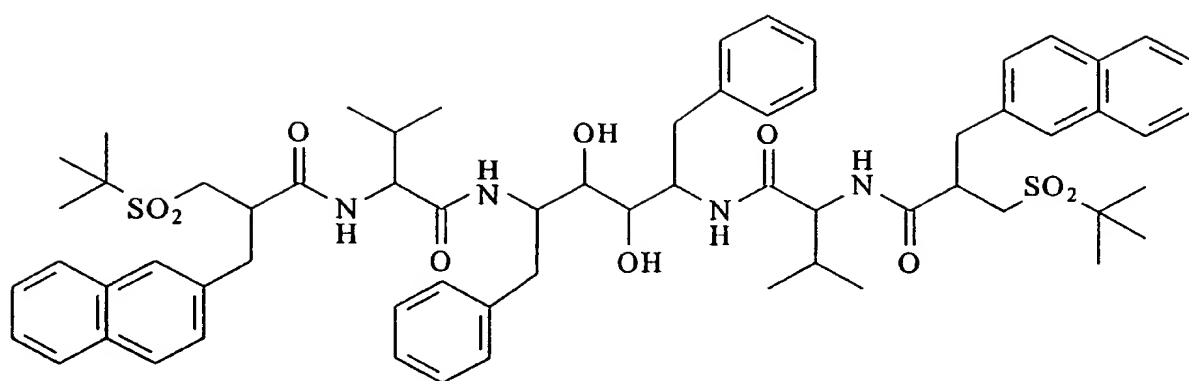


FIG. 4